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ABSTRACT

This publication, produced by the Pennsylvania Cooperative Extension Service, is a non-technical guide to chemical control of aquatic vegetation. The purpose of this circular is to aid the land owner or manager in managing ponds, streams, and other water bodies for desired uses by managing the vegetation in, on, and around the water. Among the topics discussed are the growth and various types of algae; growth and types of flowering aquatic plants; the effects of the environment on growth; the contributions of aquatic plants to the environment; pollution associated with aquatic plant growth; and management and control of aquatic plants, including mechanical, environmental, and chemical controls. The chemical controls section briefly discusses treatments for various plant types and the possible effects of those treatments as well as dosage calculations, equipment, and application techniques. A short summary and a card showing various aquatic plants with recommended herbicide names are also included. The last half of the publication is a catalog of common aquatic plants. (MR)

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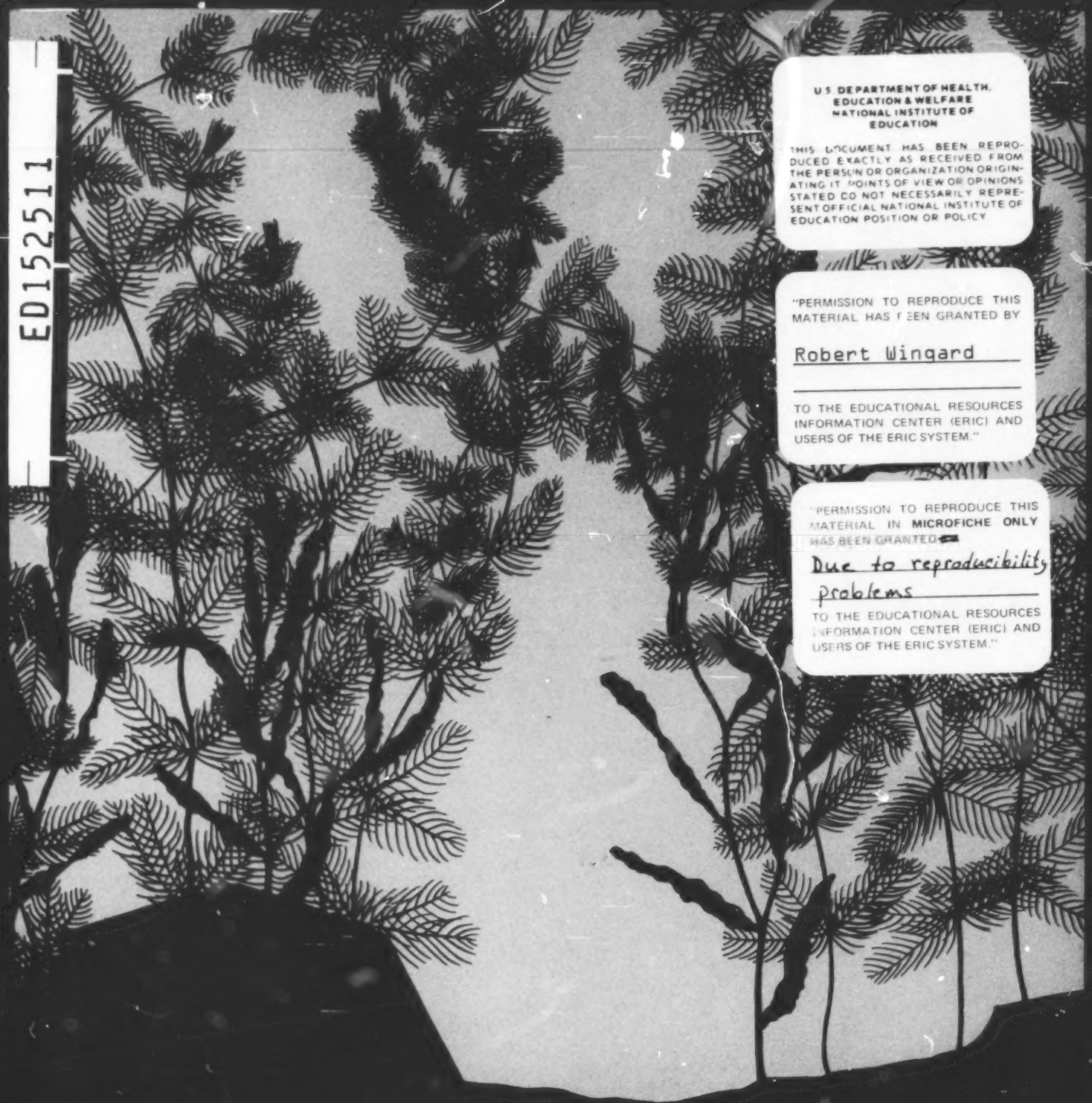

AQUATIC PLANTS

Management and Control

SE 023 926

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THE PROBLEM

Water areas, like land areas, support plant life. The kinds and amounts of plants vary within different aquatic environments — streams, rivers, lakes, ponds, marshes, and other wetlands. Aquatic plants may be the dominant feature of some water areas. In other cases, they may occupy only the water margin, or may grow profusely out of sight beneath the water surface or may grow as minute particles suspended in the water. Aquatic plants belong to two groups — flowering plants and algae.

Uses and management objectives for a body of water determine the need for management or control of aquatic plants. A given body of water may be used for recreational purposes such as fishing, boating, swimming, water skiing, and duck hunting. In addition, domestic, industrial, and agricultural uses may influence management objectives so that aquatic plants should be considered in the overall management program for a pond or lake.

Overabundant floating and submerged plants can interfere with boating, fishing, and swimming. In fact, dense plant growth can make swimming hazardous. Swimmers object to greenish water resulting from plankton algae blooms. Rooted emergent plants along the shoreline may make it difficult to launch boats and may limit the usefulness of beach areas. Dense vegetation also interferes with fish propagation, hatchery operations, and fishery management. Aquatic plants, particularly several species of algae, may give water a disagreeable flavor or odor and make it unfit for drinking without treatment. This undesirable flavor may also be imparted to fish flesh through the food chain. Free-floating aquatic vegetation often clogs irrigation pipes and nozzles. Some aquatic plants may restrict industrial withdrawals of water.

On the other hand, aquatic plants may be desirable for special purposes. Certain plants and seeds are useful as cover and food for wildlife. Cattails have value as human food. If fishing is a major interest, a limited number of aquatic plants — both floating and submerged — may be desirable. They provide fish with cover, food, and a spawning site.

The desirability of aquatic plants depends on the point of view of the water user. Reservoir managers and swimmers want clean, clear water that is free of weeds, algae, and other organisms. Waterfowl enthusiasts want an abundance of aquatic plants that attract ducks and geese. Anglers like lily pads, weed beds, and plankton that nurture fish, but not if they become widespread and constantly tangle hooks and lures. Conservationists strive for suitable plant cover on watersheds and banks of streams, lakes, and ponds to control erosion and to protect water quality. The owner or manager of a body of water should be knowledgeable about aquatic plants so that he can choose plant management procedures to meet his objectives. The application of science to management of aquatic environments offers the best solution to meeting the diverse interests of all water users.

GROWTH OF ALGAE

Algae are the most common and widely distributed of all aquatic plants. Nearly all waters contain many species of plankton algae, including representatives of the green, blue-green, and yellow-green groups, as well as filamentous and muskgrass types. Algae reproduce by spores, cell division, and fragmentation.

Plankton Algae

All suspended forms of algae make up part of the great numbers of small plants and animals known as plankton. Plankton algae are the most important plants in all natural bodies of water. These microscopic plants utilize carbon dioxide, water, and sunlight to manufacture carbohydrates and other energy chemicals. Thus, they serve as the beginning of food chains which support most higher forms of aquatic life. In large numbers, plankton algae may color water brown, yellow, pea-soup green, or even red during the warm seasons of the year. When this occurs, a lake or pond is said to have a bloom. This bloom may (indirectly) provide food for fish, but it also may make water undesirable for swimming or fishing or for use as a domestic water supply. During a bloom each ounce of water contains millions of microscopic algae cells.

Filamentous Algae

Many algae can be seen without a microscope when they occur in masses. Some grow as long strands or filaments. The strands form floating mats, often called pond scum. Other species of filamentous algae may form a green, fur-like coating on stones and other objects.

Muskgrass Algae

Another type of algae, muskgrass or stonewort, occurs in quiet waters in areas with limestone soils. These plants have a strong, musky odor and are sometimes encrusted with rough, gritty calcium deposits. Plants have an erect, central main stem with whorls of branches at various intervals. They may grow 2 or 3 feet tall, and may completely cover a pond bottom. Because of their appearance and growth form, these species of algae may be mistaken for flowering plants.

GROWTH OF FLOWERING AQUATIC PLANTS

The most conspicuous aquatic plants belong to the flowering group. These aquatic plants vary from tall cattails to tiny duckweeds only one-eighth inch across; from thick-stemmed, leathery-leaved waterlily to delicate, fragile-leaved watermilfoil.

Aquatics reproduce by various methods. Some plants reproduce from seeds which may be carried to new aquatic locations by water currents, by wind, or by birds that ingest the seeds and deposit them in their droppings. Some seeds germinate immediately, while germination in others may be delayed for several years.

Many aquatic plants also reproduce vegetatively, by runners and fragmentation. Species that reproduce by fragmentation can spread rapidly. When pieces break off, the fragments float with the current, grow new roots, anchor, and thrive in another area.

Species such as coontail and pondweed develop buds in late summer and fall. Winter buds are reproductive structures that enable the species to survive the rigorous cold season and produce new plants the following spring.

Aquatic plants usually are divided into three categories based on their growth characteristics: submergents, emergents, and floaters.

Submergents

These plants grow in the deeper water and usually are attached to the muddy bottom. They generally grow under water except at flowering time. Flowers protrude a short distance above the surface, where wind and insects aid in pollination. After pollination, the flowers and stalks may withdraw below the surface, where the fruits mature. Pondweeds, common elodea, coontail, and watermilfoils are among the common submergents.

Emergents

These plants grow along the shoreline in shallow water and are sometimes called marsh plants. Their roots, imbedded in the bottom of the pond, obtain mineral nutrients from the soil. Their stems, leaves, and flowers are almost entirely above the water line. Emergents include cattails, arrowheads, rushes, reeds, and sedges. These may grow in moist bog locations or in deeper water. Spear-like, grass-like, or arrow-shaped leaves are found on many aquatic plants in this group. Varied leaf forms, which are related to water depth, sometimes complicate identification of certain emergents. For example, leaves on the same species of arrowhead may vary from straight, spear-like blades to broad, arrow-shaped blades.

Floaters

Floating aquatic plants are usually found in relatively shallow water. Attached floaters, such as waterlilies,

watershield, and spatterdock usually are rooted in the mucky bottom and absorb their nutrients from the mud. Leaves and flowers either float on the surface or rise slightly above the surface, and the flowers are pollinated by insects. Thick masses of floating leaves reduce the amount of light reaching the bottom, thus limiting the growth of submerged plants. Dangling roots of free-floating plants, such as duckweed, obtain nutrients directly from the water. Heavy growths of duckweed may cover the entire surface of small ponds.

ENVIRONMENT AND GROWTH

Environmental factors which inhibit aquatic plant growth are deep water, moving water, steep shoreline slopes, unstable bottoms, cold water, colored or muddy water, and low fertility. In contrast, lakes or ponds producing dense aquatic plant growth usually have several of the following characteristics: shallow depth, gently sloping shoreline, stable bottoms, warm water, clear water, and high fertility.

Soft water has a low mineral content, which results in low ferility. Ponds or lakes containing soft water often have sparse vegetation composed of pondweeds, bladderworts, and watermilfoils. Hard water has high mineral content and high fertility. Ponds containing hard water often support a dense growth of many species.

Mineral nutrients constantly move into aquatic ecosystems by natural processes such as rainfall, erosion, and leaching. Fertility of soft water impoundments is increased by drainage from forests, farms, and urban centers. When drainage from livestock operations or effluent from septic tanks and waste disposal systems enters a pond, the fertility is increased greatly. Aquatic plants grow best in fertile waters.

Composition of mud on lake and pond bottoms influences the number and species of plants that will grow. Most aquatic plants grow best in a mixture of sand and organic soils. Soft, mucky soils may be unfavorable to aquatic plants.

CONTRIBUTION OF PLANTS

Energy

Aquatic plants, like all other green plants, use energy from the sun to manufacture carbohydrates. Part of the energy obtained is essential for the growth of the plant itself. The excess energy is stored in the form of carbohydrates, oils, and other products. This stored energy supports most animal organisms in aquatic environments. Submerged aquatic plants contribute to the well-being of animals in a water environment by taking up carbon dioxide and releasing oxygen during photosynthesis.

Food Chain

Algae and flowering aquatic plants form the basis of the food pyramid, or the first link in food chains. These plants are called producers, and must be present in great abundance to support aquatic animals called consumers. Organisms that feed directly on plants are called primary consumers. Part of the energy transferred to consumer organisms through food is used in growth of primary consumers, and excess energy is stored. The primary consumer is eaten in turn by the secondary consumer, and so forth. This cycle of energy use and storage is repeated through higher levels of the food pyramid. Fewer individual organisms can be supported at the top of the food chain than at its base.

Submerged stems and leaves of flowering plants serve as hosts for a whole community of microscopic organisms. This entire community contributes to food chains of ponds and lakes. Principal organisms living on and around larger plants are: bacteria, fungi, algae, diatoms, protozoans, insect larvae, thread worms, bristle worms, rotifers, and small crustaceans. The populations of this communtiy are spread over leaf and stem surfaces in increasing numbers until the end of the summer. This microscopic community provides support for the larger organisms, including fish.

Animal Habitat

Underwater plants contribute in another way to the ecological structure of the aquatic community. Many free-living and swimming creatures, such as fish and amphibians, deposit eggs in plant beds. The young of many fish use these beds for shelter from predators, and for a source of food.

Fishermen and the game fish they seek are at the top of the food pyramid. The presence of green plants, especially plankton algae, is important to successful sport fishing.

Aquatic plants provide habitat for many wildlife species that are adapted to live in aquatic areas. Furbearers seek the bank vegetation for cover and use vegetation for building their houses and lining their dens. Muskrats and beavers feed on the rootstocks and stems of plants such as cattails, arrowheads, and waterlilies. Most species of waterfowl nest in habitat created by emergent vegetation along pond margins. Pondweed seeds, arrowhead tubers, bulrush seeds, and smartweed seeds are favorite duck foods. Turtles, such as snappers and small painted turtles that frequent ponds, feed on a variety

of submerged vegetation. Aquatic vegetation may provide habitat needs for other animals such as shorebirds, water snakes, salamanders, frogs, and toads.

Filling

In the course of thousands of years, a pond or lake will fill and become dry land. The deeper the lake, the longer it will take to fill. This filling process is aided by the growth of aquatic plants in several ways. The continued cycle of plant growth and decomposition contributes to a slow accumulation of organic matter in the basin. Plants also retard the flow of water, which causes suspended material to settle to the bottom. As the filling progresses, plants of the shallower zones become established in the formerly deep zones. Most bogs and swamps are former lakes in which filling processes are nearly complete.

WATER POLLUTION

Two types of pollution associated with aquatic plant growth are: pollutants which inhibit growth and those which stimulate growth. Although both forms can be serious, the main concern in ponds and lakes is with the growth-stimulating pollutants.

The primary materials that stimulate growth are nitrates and phosphates discharged in sewage plant effluent, home waste disposal systems, food-processing plants, and well-fertilized agricultural watersheds. These materials stimulate profuse growth of both algae and flowering aquatic plants.

Depending on conditions, water in a polluted pond or lake may be either excessively colored with a plankton bloom or clear and choked with weeds. Either condition indicates water of relatively high fertility and optimum conditions for algae or for larger plants. These conditions often are created by wastes from developments on the watershed. Treatment of wastes by sewage treatment plants or by individual disposal systems may not remove nitrates and phosphates.

Fish Kills

Dense aquatic plant growth may cause oxygen depletion and subsequent fish kills. Warm, calm, cloudy weather in summer or thick, opaque, or snow-covered ice in winter contribute to this hazard. Under these conditions, plants do not produce as much oxygen through photosynthesis as they consume through respiration; some may die and decompose. Organic decomposition occuring throughout the year makes a continuous demand upon available oxygen. If oxygen is not available through wave action, inflowing water, or photosynthesis, oxygen may be reduced to levels inadequate for survival of fish and some of their food organisms.

MANAGEMENT AND CONTROL

Aquatic plants fulfill many natural functions. They become objectionable weeds when excessive growth interferes with uses of the pond. For example, spatterdock offers a desirable habitat for various species of fish and is pleasing to look at, but a patch of spatterdock becomes a nuisance when it clogs the area around a boat dock. Ponds and lakes with a variety of uses are likely to have aquatic plants that are considered desirable by some groups and objectionable by others. Compromise may be necessary in managing the vegetation in a pond or lake.

The first step in managing aquatic plants is to identify the problem species. Along with identification, learn the growth characteristics and life history of the problem plants. Aquatic plants can be identified and a management or control program can be planned with the help of illustrations and information in the Catalog of Aquatic Plants. If the plant cannot be identified from this information, collect a complete plant specimen, spread it out on newspaper, press and dry it, then have the County Cooperative Extension Service staff assist in identifying the plant. Be sure the specimen is as complete as possible, including roots, stems, leaves, flowers, and seeds.

Then select a method for controlling the troublesome aquatic plants. These choices are: mechanical, environmental, and chemical. They can be, and often are, used in combination.

Mechanical and Environmental Controls

Physical removal is most effective for small quantities of plants near shorelines. The technique consists of cutting, mowing, raking, digging, or pulling. In small ponds or lakes, emergent plants such as sedges, cattails, and rushes can be mowed, pulled by hand, or dug with a hoe. Small patches of waterlilies or spatterdock can be controlled by cutting or pulling before extensive growth occurs. Pulling or cutting must be repeated several times to eliminate new growth as it appears. Single treatments usually are not effective because of the extensive root systems of some aquatic plants.

Attempts to remove submerged plants by cutting or pulling seldom are effective. Actually, this practice may cause spreading of certain species because stem fragments left in the water may establish new plants.

Thin sheets of black plastic have been placed on pond bottoms to discourage plant growth. This technique can be especially effective in small ponds and where control is desired around boat docks or at the edge of weed beds.

Deepening shallow ponds or lakes offers the most permanent method of preventing aquatic weeds. The cost of deepening man-made lakes and ponds may be high at the time they are constructed, but it is even more expensive to deepen them after they are built. In ponds where most of the water is over 10 feet deep, submerged vegetation seldom becomes a serious problem. Sunlight penetration at this depth usually is not sufficient to stimulate vigorous growth of aquatic plants.

Seasonal control of some species, including watermilfoils and pondweeds, has been achieved by partially draining ponds in late fall or early winter. Plants usually are killed or rootstocks frost-heaved if the bottom mud freezes to a 4-inch depth for a period of 3 weeks or longer. Use caution in prolonged drawdowns. Oxygen depletion is more likely to occur when fish and organic debris are concentrated in a smaller volume of water.

Pond embankments and steep sides that drop off rapidly into deep water will usually limit aquatic plant growth to the very edges of the pond, where emergent plants may be easily cut or removed by other mechanical means. However, steep sides may create other problems. Steep sides may be a safety hazard to small children, equipment operators, and swimmers.

Successful reproduction of fish such as pickerel and golden shiners requires shallow water and some aquatic vegetation. Where desirable fish are dependent on plants, portions of the pond should be left untreated. Aquatic plants protect small game fish against predation, but excessive plant growth can provide too much protection for undesirable species.

Fertilizer added to a pond or lake may stimulate the growth of plankton and change the environment. In the warm season, fertile waters become greenish or brownish, indicating the presence of millions of minute plants and animals. This bloom restricts the penetration of sunlight, which in turn inhibits photosynthesis and supresses the growth of submerged plants.

The results of fertilization in Pennsylvania are unpredictable. Addition of fertilizer should be considered only when a body of water is small (a few acres or less), the rate of water exchange is slow, and production of warm-water fish is the prime objective. Pond fertilization usually sitmulates existing aquatic plants and increases the weed problem instead of reducing it.

Animals that feed on aquatic plants are of limited value for the control of these plants. Muskrats may cut considerable quantities of plants, but in doing so they leave fragments that may act as sources for plant propagation. Domestic waterfowl may feed on certain floating and submerged plants; however, the fertility resulting from their excrement may create excessive algae blooms that may be less desirable than the original problem. Some exotic species of fish such as the white amur are being promoted to control aquatic vegetation. Since the impact of these fish on aquatic ecosystems is not fully known, the possession or release of these fish into waters of the Commonwealth is prohibited by the Pennsylvania Fish Commission.

Chemical Controls

Herbicides offer a solution to many otherwise difficult aquatic weed problems. But chemical control has its own set of limitations. Chemical treatment must be performed carefully, the correct chemical must be selected for the identified problem plant, and precise measurements of water volume and chemicals must be made. Failure of the herbicide to control the weed will result from using the wrong herbicide. Inadvertent damage to fish may result from incorrect application rates.

Regulations have been established which allow individuals to apply for a permit to use algaecides, herbicides, and fish control chemicals. Permits for the use of aquatic herbicides are issued with joint approval of the Fish Commission and Department of Environmental Resources in fulfilling their responsibility under the Clean Streams Law and the Fish Laws (see back cover). *THESE PERMITS ARE REQUIRED TO CHEMICALLY TREAT ANY WATERS OF THE COMMONWEALTH.*

When chemical treatment is planned, obtain an application form. A sample application for a permit is included on the back of this publication. Submit the application (properly completed, signed, and witnessed) to the address given on the form. Be sure to include the name of the plants to be treated, the name of the chemical, and rates of application. Obtain a copy of *Aquatic Plant Herbicides* for the current year to assist in selecting the proper chemicals for the problem plant. Copies are available from county Cooperative Extension Service offices.

Anticipate the following effects from the use of aquatic herbicides, since elimination of a dense growth of vegetation often results in significant changes in the lake or pond. Following the death of larger weed plants, a greenish or yellowish-brown color may develop. This condition is due to the presence of millions of microscopic plankton algae which have utilized the nutrients for growth and reproduction. The blue-green algae are often responsible for a green pea-soup appearance, whereas other algae and various one-celled organisms cause the yellowish-brown color in water. When conditions are best for development of algae, a dense bloom can develop quickly. These dense blooms cut down light penetration and thereby inhibit the reestablishment of plants killed in treatment, but the algae may turn out to be more objectionable than the original weed infestation.

Many herbicides are toxic to fish and other animals, including human beings. But the amounts needed to kill

aquatic weeds are less than the tolerance level of fish and other animals. Newly hatched fish appear to have less tolerance to herbicides than do older fish. In some areas, minor fish kills may occur when safe dosages are exceeded due to an uneven distribution of the chemical.

Fish mortality may also occur as an indirect result of chemical weed control because oxygen is consumed by the rapid decay of plants. To minimize this danger, treat only one-third of the pond at any one time, even when plants are present in the entire pond. Make applications at least one week apart, or as specified on the label, so that rapid plant decay will not reduce oxygen content of the water to a dangerously low level. Chemical control of aquatic weeds must be undertaken with considerable care and adequate planning.

Algae

Chemicals for algae control are available in liquid, granular, powder, or pellet formulations. All will produce good results if they are properly applied. Applications should be made on warm, sunny days; under these conditions algae are growing vigorously and are most vulnerable.

Control is most effective and least costly when undertaken before the algae become dense enough to constitute a serious problem. Through experience with a given body of water, one may be able to anticipate when chemicals should be applied.

If copper compounds are used, the amount and the number of required treatments vary with the hardness of the water. In soft water, one treatment is enough. In hard water, 3 or 4 treatments may be needed throughout the summer because the regrowth of algae may be quite rapid in such water. If results are not evident within 7 days after treatment, another application may be required.

Trout are very sensitive to some chemicals and cannot tolerate levels required for control of certain species of algae. Do not use copper compounds in ponds when trout are present. Other fish cannot tolerate levels much in excess of those required for algae control. Fish in soft-water lakes and ponds are particularly vulnerable to algaecides containing copper.

Repeated applications may reduce fish populations either through direct toxicity or through indirect elimination of sensitive fish food organisms.

Submerged plants

Submerged plants complete their entire life cycle, exclusive of flowering and pollination, under water. Common elodea is typical of submerged plants that grow in dense stands or mats. Other troublesome submerged species include pondweeds, watermilfoils, coontail, and bladderworts.

Chemicals for controlling submerged weeds can be applied in various ways. Liquid herbicides may be poured, sprayed, or pumped into the water. Wettable powders should be applied as a slurry according to label instructions. As a rule, the more evenly the chemcial is distributed, the better the results will be. Spot treatment of submerged plants may be feasible, although adjacent water will have a diluting effect.

Granules may be spread from a boat or from the shore. Care must be taken to obtain uniform coverage. Granules are especially useful for spot treatments near boat docks or swimming areas. Granular formulations act more slowly than liquids, but they may give more long-lasting results. Granules settle to the bottom and release the chemical that will be absorbed through the plant roots. If granules are spread on choppy water, distribution will be uneven, and results may be unsatisfactory.

Emergent plants

Emergent plants may grow in moist or swampy shoreline soils and extend into water 3 feet deep. Many emergents are valuable as duck foods and should not be eliminated if waterfowl are wanted. Principle types include species of rushes, bulrushes, cattails, reeds, sedges, and arrowheads.

Foliar sprays should be applied in early summer when the leaves are approaching full size but before the plant produces flowers. If water is used as the diluent or carrier, additon of a small amount of detergent or other wetting agent will improve coverage of the plant surfaces. The plant foliage should be completely wetted. Applications should be made during midday periods when the above-water foliage is free from dew or rain.

Floating Plants

The most common species of floating plants are duckweeds, waterlily, spatterdock, and watershield. These floating plants are valued by fishermen as long as ample room is left for fishing. But in areas used for boating, swimming, or water skiing, floating plants may be serious nuisances requiring control.

Granular formulations may be used for floating plants that are rooted on the bottom. Free-floaters, such as duckweeds, must be treated with liquid formulations.

Treat plants and the water surface, taking care to obtain even distribution in the area of plant growth.

Dosage calculations

Accurate calculations and proper application procedures are critical when applying aquatic herbicides. In order to calculate the amount of chemical to be used, it is

necessary to measure the water area and average depth.

If the pond or lake is square or rectangular, with relatively straight sides, take several measurements to determine average length and average width. Make certain to measure the longest and shortest distances in determining these averages. Then multiply the average length by the average width measurement to get the surface area in square feet. For example, a pond with an average length of 600 feet and an average width of 145 feet has 87,000 square feet.

If the pond is circular, take several measurements of the diameter, then determine the average of these measurements. Divide the average diameter by 2 to get the length of the radius, then use the formula (Area = 3.1416 x radius squared) to determine the surface area in square feet. Since one acre contains 43,560 square feet, divide 43,560 into the number of square feet to obtain surface acres. In the example pond, 87,000 square feet divided by 43,560 equals 2 surface acres. Some chemical applications are made on the basis of surface acres.

The measurement most commonly used to determine application rates of aquatic herbicides is acre foot. One acre foot is that volume of water which will cover one acre to a depth of one foot. To find average depth, take depth measurements at various points along the length and width of the pond. Include measurements from the deepest and shallowest areas. When determining average depth, use a maximum of 10 feet. This is due to the fact that practically all aquatic vegetation lives in water less than 10 feet deep. To calculate acre feet in the pond, multiply surface acres by average depth. If the 2-acre pond in the previous example has an average depth of 8 feet, the pond would have 16 acre feet of water. Nearly all aquatic herbicide labels provide tables showing application rates based on the number of pounds or gallons of commercial product per acre foot. The amount of chemical to apply can be read directly from these tables.

The amounts of aquatic herbicides used result in concentrations of chemical in proportion to water that are so low that concentrations sometimes are expressed in parts per million (ppm). If a 1 ppm concentration of the active ingredient in a herbicide is recommended for control of an aquatic plant, this means that the chemical must be applied in the ratio of 1 part active ingredient to 1 million parts of water by weight.

For chemicals whose labels give application rates in ppm some additional calculations are necessary. The number of pounds of water in one acre foot is 2.7 million. To find the number of millions of pounds of water in a pond, multiply the number of acre feet by 2.7. For our example pond, 16 acre feet times 2.7 would give us 43.2 million pounds of water. For an application of 1 ppm of a chemical with 100 percent active ingredient, we would need 43.2 pounds of chemical.

Equipment

Equipment needed to apply aquatic herbicides depends on the formulation and type of material. While uniform coverage is desirable, it is rarely attained. Small skips or untreated areas are not a serious problem because diffusion and water currents rapidly distribute the chemicals. Dry formulations require more uniform distribution than liquid formulations.

Some liquids are applied uniformly by pouring the herbicide directly from the container into the water. Other liquids should be sprayed above the surface, or injected beneath the water to prevent drift. The 3- to 5-gallon pressure-type sprayers, available at garden centers or farm supply stores, are adequate for treating small ponds. Commercial-type sprayers may be more efficient for large lakes. Some wettable powders should be placed in a bucket and mixed with water to form a thin paste or slurry. Toss the slurry into the pond from the shoreline. Granules can be spread by hand or by hand-operated crank-type fertilizer and seed spreaders. Pellets should be evenly distributed by hand. Use a boat and follow a zigzag pattern to make uniform applications.

Application techniques

Apply chemicals in accordance with the manufacturer's label instructions. These instructions generally include recommended equipment, dosage,and suggested time of application. Instructions are specific for the plant species to be treated. Proper equipment saves time and labor and permits uniform application. Herbicides should be applied when the plant is most susceptible, and the dosage used must never exceed the amounts listed on the label. Do not treat aquatic plants when the water is colder than 60°F.

Only the active ingredient of commercial herbicides is the effective controlling agent. Label dosage is based on the amount of active ingredient. Herbicides with low percentage of active ingredient will contain a large amount of inert material and will have a relatively low unit cost. Herbicides with a high percentage active ingredient will have a high unit cost but will require less material for a treatment.

Chemical herbicide sprays should be applied on a calm day when dangers from drifting can be avoided. With such precautions, damage to desirable vegetation is avoided, and operators are protected from excessive contact with, and inhalation of, spray.

Chemical spills must be cleaned up, especially around stock pond areas or where pets and children may be exposed. Herbicides should never be stored within reach of children. Labels should be studied and their instructions for safe and proper use observed.

Herbicide application should start at the margins of the lake or pond and progress toward the deep water. Fish and other organisms will tend to move ahead of the herbicide-treated water into the deeper areas, where toxic concentrations can be avoided.

In those lakes and ponds that have a high rate of inflow, water level should be lowered prior to treatment so as to insure adequate contact time for the herbicide. The amount of drawdown will vary according to the situation, but the treated water should be retained for several days if possible.

After the application is completed, equipment should be flushed with large quantities of water. Do not use herbicide application equipment for any other purpose.

Waters should be treated for aquatic weeds in late spring or early summer when plants are young and actively growing. Treatment at this time of year usually gives best control with the least amount of chemical. Applications in late summer or early fall require more chemical and usually give slower, erratic control. Furthermore, access to normally dense aquatic vegetation is best in the spring or early summer before the plants reach the surface.

Points to remember:

1. Be certain to identify the vegetation to be treated.
2. Select a suitable registered herbicide to control it.
3. Obtain a permit to chemically treat any waters of the Commonwealth.
4. Never use more chemical than suggested on the label.
5. Use treated water only as specified on the label.

SUMMARY

Aquatic plants provide habitat in lakes and ponds for many aquatic organisms, but excessive growth may conflict with certain types of water use.

Aquatic plants add essential oxygen to the water, but under some conditions their respiration and decomposition may reduce the oxygen to dangerously low levels for fish survival.

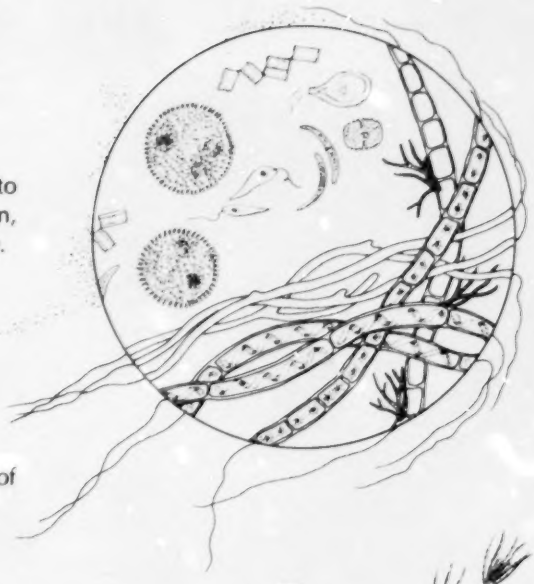
Aquatic plants play an important role in food chains; however, too many plants may contribute to over-crowded and poor quality fish populations.

There is no easy cure-all for controlling undesirable aquatic vegetation. Mechanical removal or environmental changes should be considered. These methods may be safer, less expensive, and longer lasting than herbicide treatments.

Aquatic plant control with chemicals can be successful and satisfactory. Once a weed problem is under control, diligent treatment of regrowth is necessary to maintain control. It is much easier and less expensive to conduct periodic maintenance or to make spot treatments than it is to wait until treatment of the entire area is necessary. Chemicals for control of certain plant species, even though successful, are not likely to end all problems in themselves. Owners and managers can use a variety of techniques to limit aquatic plants without causing harmful side effects to man or other desirable organisms.

CATALOG OF AQUATIC PLANTS

ALGAE



Plankton algae are minute, free-floating plants that cause water to have a greenish or brownish color. Overabundant plankton, referred to as a bloom, give the water a pea-soup appearance.

Filamentous algae consist of long strands, filaments, or nets of plant material that often form floating mats.

Muskgrass, or **stonewort**, **algae** have the appearance of flowering plants. They occur in hard water in limestone areas, they are often rough and gritty to the touch, and give off an ill-smelling skunk-like odor when crushed.

Muskgrass algae are upright plants with stems and whorled branches. Each joint of the stem consists of a single cell. Even-length branches are clustered at each joint. They reproduce by spores borne in cases near the branch tips.

SUBMERGENTS

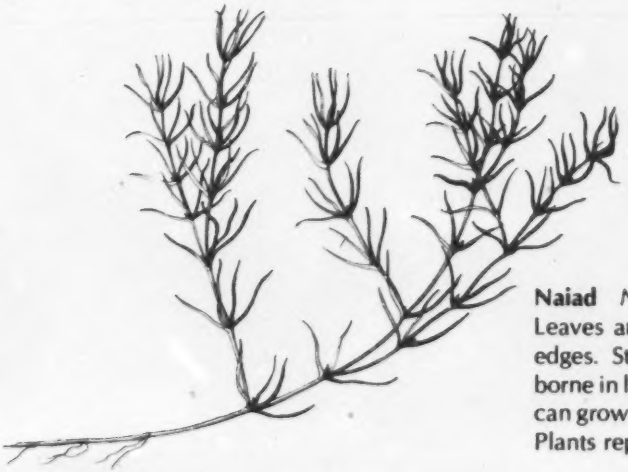
Submergents are aquatic plants, usually rooted on the bottom, whose stems and leaves are almost always entirely beneath the surface.

Bladderwort *Utricularia spp.*
Unique characteristics are tiny oval bladders borne near the base of the finely divided leaves. Plants lack true roots and may float free beneath the surface. They are found in cold, acid water and reproduce by winter buds. Flowers are yellow or purple, depending on the species.

Common Elodea *Elodea canadensis*
Leaves are densely whorled or opposite on the stem. They are common plants used in home aquaria. Flowers inconspicuously rise to the surface on thin tubes, then withdraw. These plants reproduce from fragments and rarely set seed.

Coontail *Ceratophyllum demersum*
Leaves are whorled at each joint. The leaflets, which are forked once or more, have toothed edges. Leaves are densely crowded near the tip of the stem, giving an appearance of a coontail. Flowers are inconspicuous. Roots may be absent, leaving the plants floating beneath the water surface. They are found in hard water, tolerate fluctuating water levels, and reproduce from plant fragments and winter buds.

Fanwort *Cabomba caroliniana*
Leaves are opposite or whorled and fan-shaped. Forked leaflets are wider at tip than at the base. Some plants may have small floating leaves. Plants have a gelatinous slime. Inconspicuous flowers are white to lavender. This species also reproduces by plant fragments. They are common aquarium plants introduced from the south.



Naiad *Najas spp.*
Leaves are whorled or opposite, very narrow, and toothed on edges. Stems are much branched. Inconspicuous flowers are borne in leaf axils. Plants need less light than most aquatics so they can grow in deep water, but commonly found at 1 to 4 foot depth. Plants reproduce by seeds.

Pondweed, Curly *Potamogeton crispus*
Leaves are alternate, with finely toothed, crinkled, or puckered edges. There are no floating leaves on this pondweed. Flowers and seeds are in a spike at the tip which extends above water for fertilization. They are found in fertile, hard water and reproduce by seeds and winter buds. The plant was introduced from Europe.

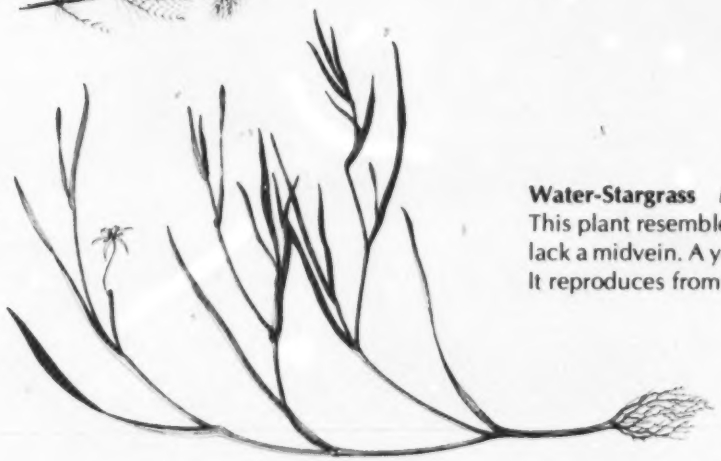
Pondweed, Leafy *Potamogeton foliosus*
Several species of pondweed have narrow, grass-like leaves with sides essentially parallel. In some species the sheath at the base of the leaf, seed shape, and other botanical characteristics are used to identify the species. Leafy pondweed has leaves about 1/16" wide, without a sheath at base. Flowers and seeds are in leaf axils. Leafy pondweed reproduces by winter buds and seeds.

Pondweed, Sago *Potamogeton pectinatus*
Leaves are fine, thread-like, and they spread as a fan. Stems usually are multi-branched. Leaves have a sheathed base. Flowers and seeds are borne on a terminal spike. Tubers grow from horizontal rootstocks. There are no floating leaves on this pondweed. Plants reproduce by tubers and seeds.

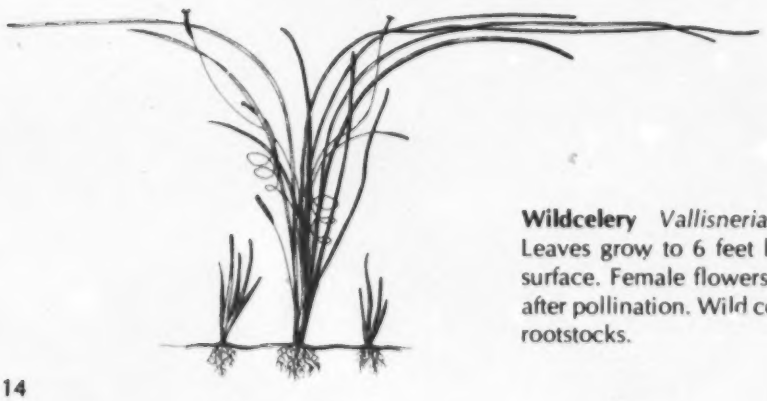
Pondweed, Floating *Potamogeton natans*
Two types of leaves are common. Underwater leaves are narrow, grass-like, and appear as stalks. Floating leaves are oval to heart-shaped each with a notched base. Flowers and seeds are borne on a terminal spike. Plants reproduce by tubers, seeds, and winter buds.

Watercress *Nasturtium officinale*
Watercress grows in tangled masses. Leaves are compound with 3 or more segments, of which the terminal is largest. Roots form at stem joints. Flowers are white. Watercress is common in springs but may also invade shallow margins of ponds.

Watermilfoil *Myriophyllum spp.*
Leaves are whorled on a stem, and pinnately divided, as a feather. Leaves are not forked as in coontail. Flowers develop on terminal spikes with very short leaves surrounding them. A perennial aquatic, it reproduces by plant fragments. It is commonly used as a decorative plant in aquarium shops.



Water-Stargrass *Heteranthera dubia*
This plant resembles some narrow-leaved pondweeds but leaves lack a midvein. A yellow, star-like flower appears on the terminal. It reproduces from plant fragments.



Wildcelery *Vallisneria americana*
Leaves grow to 6 feet long, ribbon-like, with tips that float on surface. Female flowers are on long stalks that float, but retract after pollination. Wild celery plants reproduce mainly by buds on rootstocks.

EMERGENTS

Emergents are aquatic plants of the shallows or margins of ponds and lakes. They root in soil and may grow from the water's edge into water several feet deep. Stems and leaves emerge above water.

Arrowhead *Sagittaria spp.*
Leaves are usually arrow-shaped, but tongue-like and ribbon-like leaves occur, especially at the base of the plant or underwater. Flowers are white, 3-petaled, whorled, and grow on the tip of the stalk. Fruits are tightly-packed balls of seeds. Plant reproduces by rootstocks and seeds.

Bulrush *Scirpus americanus*
Rootstocks give rise to stems that are triangular in cross section in this species, but round in some bulrushes. Height is usually 2 to 3 feet. Flowers and seeds are borne in spikes along stem near tip. These plants may form dense stands after they have been established for several years.

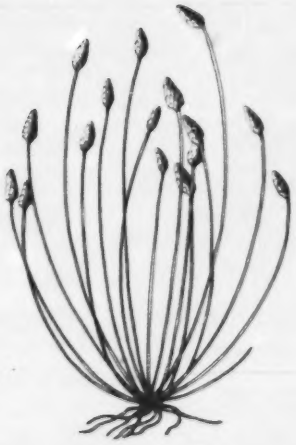
Burreed *Sparganium eurycarpum*
Leaves are long, erect, ribbon-like, and usually 1 to 3 feet tall. Stems bear male flowers at tip, and female flowers below. Fruiting heads are one-inch round balls and contain many seeds. The plant reproduces by seeds and from rootstocks.

Cattail *Typha latifolia*
Leaves reach to 6 feet tall, are ribbon-like, and taper to a point. Flowers occur on stalks which are taller than the leaves. Male flowers are at the tip; female flowers below. Cattails grow at the water's edge but are commonly found at depths of 3 to 4 feet. Plants reproduce from thick rootstocks and seeds.

Pennywort *Hydrocotyle umbellata*
Each leaf is nearly round, slightly notched, and attached at its middle. Stems creep underwater. Flowers are tiny and white, growing on stalks similar to leaf stems. This plant may grow on moist soil as well as in water and reproduces by fragments and seeds.

Pickerelweed *Pontederia cordata*
Leaves are heart-shaped and similar to leaves of arrowhead. Pickerelweed leaves have curving veins that follow the leaf margin. Arrowhead leaves are sharp-pointed whereas pickerelweed leaves are rounded. Flowers are blue and grow in a spike. Pickerelweed reproduces by creeping roostocks and by seeds.

Rush *Juncus effusus*
Stems grow 3 to 4 feet tall, resembling grasses and sedges. Clumps of stems arise from stout rootstocks. Greenish-brown flowers are borne near tip of stem. They are found in moist areas and pond margins and reproduce from rootstocks and seeds.



Spikerush *Eleocharis spp.*
Stems of this small plant arise in clumps from relatively shallow roots. The stems terminate in an oval fruiting spike. Spikerush reproduces from rootstocks and seeds.

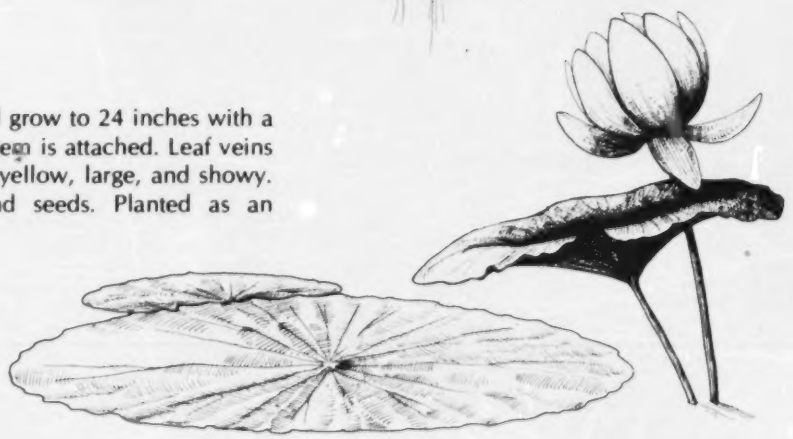
Water Smartweed *Polygonum amphibium*
Leaves are eliptical, up to 4 inches long. Stems are upright or sprawling, growing in water or on mud banks. Deep pink flowers form in terminal spikes. This species reproduces by rootstocks and seeds.

FLOATERS

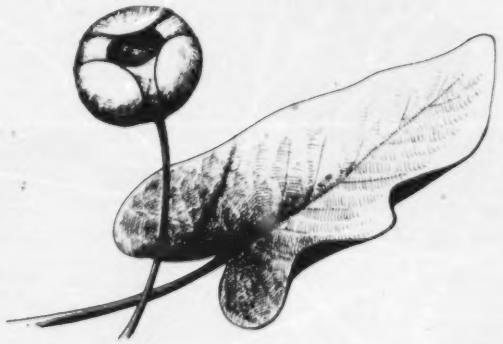
Floaters are aquatic plants whose conspicuous parts float and may move about on the surface. Attached floaters have stems, and their roots are anchored in the bottom. Free-floaters such as duckweed lack anchorage in the bottom. Duckweed roots dangle in the water absorbing nutrients directly from the water.

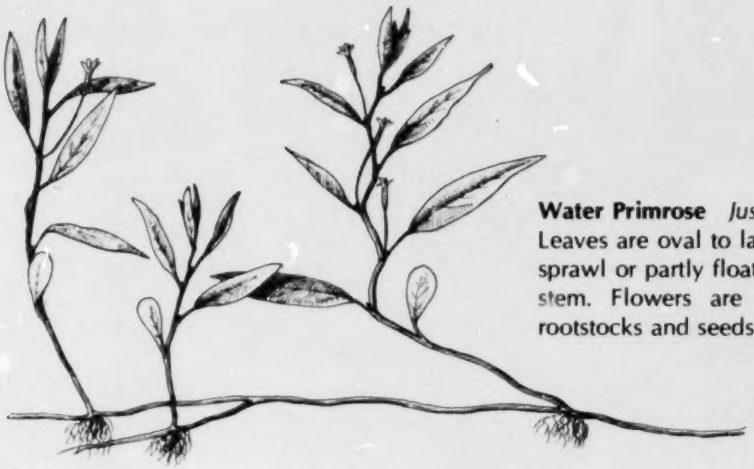
Duckweed *Lemna spp.*
These tiny free-floating plant bodies have a single ropt that dangles in the water. Several plants often are attached together. These are among the smallest of flowering plants. Flowers are borne on edges. This plant reproduces rapidly by plant division, often forming a floating mat over a considerable area of a pond.

Lotus *Nelumbo lutea*
Floating leaves are round, entire, and grow to 24 inches with a depression in the center where the stem is attached. Leaf veins radiate from the center. Flowers are yellow, large, and showy. Lotus reproduces by rootstocks and seeds. Planted as an ornamental.

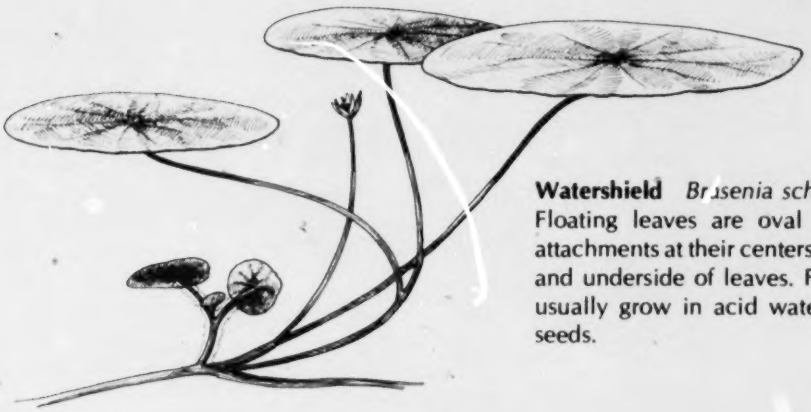


Spatterdock *Nuphar luteum*
Leaves are round to heart-shaped, and grow to 12 inches long with a distinct midrib. Most leaves extend above water. Flowers are yellow-green outside; yellow to reddish inside. Spatterdock tolerates fluctuating water levels and reproduces by rootstocks and seeds.

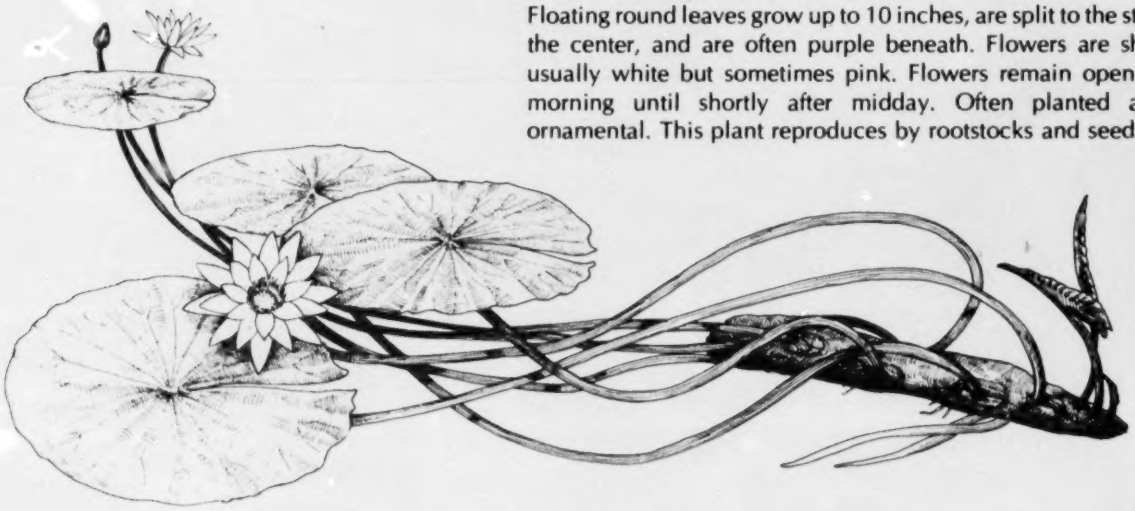




Water Primrose *Jussiaea repens*
Leaves are oval to lance-shaped, grow to 3 inches long. Plants sprawl or partly float in shallow water. Rooted at nodes on the stem. Flowers are yellow. Water primrose reproduces by rootstocks and seeds.



Watershield *Brasenia schreberi*
Floating leaves are oval to eliptical, entire, and have stem attachments at their centers. A gelatinous coating occurs on stems and underside of leaves. Flowers are dull-red to purple. Plants usually grow in acid water, and reproduce by rootstocks and seeds.



White Waterlily *Nymphaea odorata*
Floating round leaves grow up to 10 inches, are split to the stem at the center, and are often purple beneath. Flowers are showy, usually white but sometimes pink. Flowers remain open from morning until shortly after midday. Often planted as an ornamental. This plant reproduces by rootstocks and seeds.

SUBMERGENTS

Watercress *Nasturtium spp.* Endothall	Wildcelery *Vallisneria americana* Endothall

EMERGENTS

Emergents are aquatic plants with roots in soil and with stem and leaves that emerge above the water surface. Plants generally grow in shallows or margins of the ponds or lakes but may extend into water that is several feet deep.

Arrowhead *Sagittaria spp.* Endothall Silvex 2, 4-D	Pickerelweed *Pontederia cordata* Silvex 2, 4-D
Bulrush *Scirpus spp.* 2, 4-D	Rush *Juncus spp.* 2, 4-D
Burreed *Sparganium spp.* Endothall 2, 4-D	Spikerush *Eleocharis spp.* Endothall
Cattail *Typha spp.* Dalapon Diquat	Water Smartweed *Polygonum amphibium* 2, 4-D
Pennywort *Hydrocotyle umbellata* Diquat	

FLOATERS

Floaters are aquatic plants whose visible parts float and may move about on the surface. Attached floaters (such as waterlily) have stems, and their roots are anchored in the bottom mud. Free-floaters (such as duckweed) lack root anchorage; instead their roots dangle in the water from which they take nutrients directly.

Duckweed *Lemna spp.* Diquat 2, 4-D	Water Primrose *Jussiaea repens* Endothall 2, 4-D
Lotus *Nelumbo lutea* Endothall	Watershield *Brasenia schreberi* 2, 4-D
Spatterdock *Nuphar luteum* Endothall Silvex 2, 4-D	White Waterlily *Nymphaea odorata* Silvex 2, 4-D

Prepared by *Robert G. Wingard, wildlife management specialist; and Terry D. Rader, urban forest-wildlife specialist.*

Where trade names are used, no discrimination is intended, and no endorsement by the Cooperative Extension Service is implied.

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Issued in furtherance of Cooperative Extension work, Acts of Congress May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture and the Pennsylvania Legislature. J. M. Beattie, Director of the Cooperative Extension Service, The Pennsylvania State Unviersity. 10M677

AQUATIC PLANT HERBICIDES — 1977

Aquatic vegetation is found in all natural waters and is beneficial to aquatic ecosystems. Nutrient enrichment of lakes and ponds can result in excessive plant growth. When aquatic plants become a nuisance and interfere with planned water uses, then management and control are necessary.

For a fuller understanding of aquatic plants, their identification, and ways to manage them, obtain a copy of Special Circular 222, Aquatic Plants — Management and Control, from your Penn State County Extension Office or from the Agricultural Mailing Room, Agricultural Administration Building, University Park, Pa. 16802.

Follow these steps in aquatic plant control.

1) Identify the problem plant — Many plants can be identified by using illustrations in Special Circular 222 or another plant identification guide. When verification is needed a specimen is collected, pressed flat between newspapers, and sent to your County Extension Office or to some person skilled in identification of aquatic plants.

2) Choose control method — Consider deepening edges, lowering water levels, directing enriched runoff away from pond, mowing, raking, or pulling plants. With chemicals, consider costs, precautions and required permits.

3) If you choose chemicals — Select the proper chemical from those listed on this sheet for your identified plant. Check on local availability, comparative cost, and other limitations of herbicides. Always read the label.

4) Calculate pond area and volume — When chemicals are used, determine surface area and average depth to calculate acre feet. Chemical application rates usually are given in amounts to use for each surface acre or acre foot. Once you determine the surface area and acre feet of the pond, the precise amount of herbicide to apply can be read directly from the label.

5) Obtain permit — *A PERMIT IS REQUIRED TO APPLY CHEMICALS TO ANY WATERS OF THE COMMONWEALTH.* Applications for permits are available from County Extension Offices, Waterways Patrolmen, and Regional Offices of the Department of Environmental Resources. Be sure to include the name of the plant, the chemical to be used, and amounts to be applied. Send completed forms to: Pennsylvania Fish Commission, Fisheries Management Section, Robinson Lane, Bellefonte, Pa. 16823. Allow at least two weeks for processing, approval, and return of the permit.

6) Obtain proper herbicide — After you receive the permit, obtain the specified chemicals.

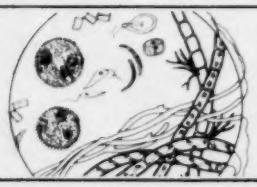
7) Follow label instructions — Apply chemicals according to label instructions printed on each container of chemicals. The instructions include recommendations for method, application rates, precautions, and any restrictions on the use of the treated water.

ALGAE

Plankton algae are minute, free-floating plants that color water greenish or brownish. When plankton algae are overabundant they are referred to as a bloom. A bloom often makes water appear as pea-soup.

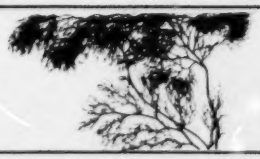
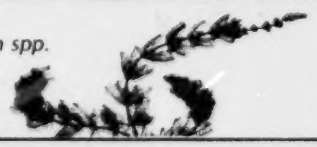
Filamentous algae consist of long strands, filaments, or nets of plant material that often form floating mats. Sometimes filamentous algae are called pond scum.

Muskgrass, or stonewort, algae have the appearance of flowering plants with a stem and with whorls of leaves or branches. Two common muskgrass algae are: Chara which is rough and gritty when crushed, and Nitella which is smooth to the touch. Muskgrass is limited to waters in limestone areas.

Plankton and Filamentous Algae		Elemental Copper Copper Sulfate Copper (Malachite) Endothall Diquat Simazine	Muskgrass and Nitella *Chara spp.* *Nitella spp.*		Elemental Copper Copper Sulfate Endothall Simazine

SUBMERGENTS

Submergents, aquatic plants which usually are rooted on the bottom, have stems and leaves that seldom appear above the water surface.

Bladderwort *Utricularia spp.*		Diquat Silvex 2, 4-D	Coontail *Ceratophyllum demersum*		Endothall Diquat 2, 4-D Silvex
Common Elodea *Elodea canadensis*		Endothall Diquat Silvex 2, 4-D	Fanwort *Cabomba caroliniana*		Endothall Silvex Simazine
Naiad *Najas spp.*		Endothall Diquat Silvex Simazine 2, 4-D	Watermilfoil *Myriophyllum spp.*		Endothall Diquat Silvex Simazine 2, 4-D
Pondweeds *Potamogeton spp.*		Endothall Diquat Silvex Simazine 2, 4-D	Water-Stargrass *Heteranthera spp.*		Endothall 2, 4-D

The Pennsylvania State University, College of Agriculture Extension Service, University Park, Pennsylvania

ER-BWQ-41 Rev 6/74

COMMONWEALTH OF PENNSYLVANIA
FISH COMMISSION — DEPARTMENT OF ENVIRONMENTAL RESOURCES —
ENVIRONMENTAL QUALITY BOARD

APPLICATION AND PERMIT FOR USE OF AN ALGICIDE, HERBICIDE OR FISH CONTROL CHEMICAL IN WATERS OF THE COMMONWEALTH

Submit all applications (only one copy necessary) to the Pennsylvania Fish Commission, Fisheries Management Section, Robinson Lane, Bellefonte, Pennsylvania 16823, Telephone (814) 359-2754

SAMPLE

1. Name of applicant (owner) _____ Tel. No. _____

   Address of applicant _____

2. Person or organization conducting treatment (if other than applicant) _____

   _____

3. Name of water body to be treated _____

4. Location of water body; County _____ Township or other municipality

   _____ _____ Nearest built-up area _____ _____

5. Type of water: Pond _____ Lake _____ Impoundment _____ Canal _____

6. Uses of water body to be treated:

   Water Supply: Municipal _____ Industrial _____ Livestock _____ Irrigation _____

   Fire Protection _____ Other _____

   Water Contact Sports: Swimming _____ Skiing _____

   Fishing: Warm water species _____ Cold water species (trout) _____

7. Is water body open for public fishing? Yes _____ No _____

8. Has water body ever been stocked with fish by a State Agency? _____ Federal Agency? _____

9. Does water body have discharge or overflow of water? Yes _____ No _____

   If YES, indicate time of year discharge or overflow will occur _____

10. Name of receiving stream _____

11. Total area of water body: Number of surface acres _____

    Treatment area: Number of surface acres _____ Average depth _____

12. Indicate species of algae, plant(s) or fish to be controlled _____

    _____ _____

13. Commercial name(s) of chemical(s) _____

(continued)

14. Dosage of each chemical per treatment (specify in either pounds or gallons)

(a) _____ per surface acre _____ per surface acre

(b) _____ per acre foot _____ per acre foot

_____ per acre foot _____ per acre foot

(c) Amount of each chemical to be applied in each treatment _____

_____ (pounds or gallons)

(d) Number of teatments to be made this year _____

(e) Total amount of each chemical to be applied in all treatments _____

_____ (pounds or gallons)

15. Proposed date or dates of treatment _____
(Local Fish Commission Waterways Patrolman MUST be contacted prior to treatment.)

16. Additional remarks or information _____

_____

SAMPLE

17. Have all other riparian users, both in the vicinity of the treatment area and downstream who may be required to restrict their usages as a result of this treatment:

(a) Approved your plans? Yes ____ No ____ (b) Agreed to restrictions? Yes ____ No ____

18. The applicant: (a) Certifies the truth of the above statements; (b) Agrees to employ the listed chemicals in conformance with the manufacturer's specifications and with all the conditions of the permit; (c) Is responsible for all damages incurred by the chemical used.

19. Applicant's signature _____ Date _____

20. Witness' signature _____ Date _____

FOR REVIEWER'S USE ONLY APPLICATION AND PERMIT NO. _____

Reviewer's Action:

Agency	Reviewer	Title	Date	Approve	Disapprove
Fish Commission					

Remarks _____

_____

Environm. Resources					

Remarks _____

_____